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【特許請求の範囲】
【請求項１】平均扁平率が１．５～５である非真円形状断面を有する熱可塑性合成繊維マルチフィラメント糸を用いた布帛に金属被膜を形成したことを特徴とする導電性繊維材料。
【請求項２】布帛が織物であることを特徴とする請求項１記載の導電性繊維材料。
【請求項３】熱可塑性合成繊維がポリエステルであることを特徴とする請求項１乃至２記載の電磁波遮蔽材料。
【請求項４】織物のカバーファクターが１０００～３０００であることを特徴とする請求項２乃至３記載の導電性繊維材料。
【発明の詳細な説明】
【０００１】
【産業上の利用分野】本発明は、合成繊維表面に金属被覆を形成した、電磁波遮蔽材やグランディング材などの導電材として用いられる導電性繊維材料に関するものである。
【０００２】
【従来の技術】電子機器からの電磁波の漏洩を防止する目的で導電性布帛がよく用いられる。その中でもポリエステル、ナイロンなどの高分子材料からなる合成繊維布帛上に金属被覆させた材料は繊維自身が有する可撓性と金属が有する電磁波遮蔽性を併せ持つものでガスケット材、テープ材として電子機器に組み込まれている。
近年電子機器の小型化、高周波化が進むに伴い電磁波遮蔽材料やグランディング材などの導電材もその厚みが薄く、高周波域での高シールド性能が求められてきている。厚みが薄く、高シールド性と言う点では金属箔や高分子フィルムに蒸着またはスパッタリング法で金属被覆を施した材料があるが電磁波遮蔽材料や導電材に求められる耐久性、可撓性および柔軟性に欠ける。
【０００３】

実開昭６４－３０８９９には扁平形状断面を有する金属メッキ繊維と熱融着バインダー繊維とが該バインダー繊維の融着により一体に接合された不織布から成る電磁波遮蔽シート状物が記載されている。しかし、熱融着バインダー繊維を用いて加熱圧着し、シールド性を向上させているので布帛の柔軟性が損なわれ、しかも、製造工程が増えるためにコスト的にも高いものになってしまう。
特開平８－２９１４３２には扁平非真円形状断面を有する金属モノフィラメントを１０本以上の繊維からなる芯糸に螺旋状に巻きつけてなる複合糸条を用いた、柔軟可撓で電磁波遮蔽性を有する織物が紹介されている。しかし、シールド性を得るには金属モノフィラメントの含有率を上げなくてはならず、繊維自身の柔軟性を損なうばかりかコスト的にも高いものとなってしまう。

【０００４】

【発明が解決しようとする課題】本発明はこのような現状に鑑みて行われたもので、繊維本来の柔軟可撓性を損なうこと無く、広帯域にわたり高シールド性能を維持する電磁波遮蔽材やグランディング材などの導電材として用いられる導電性繊維材料を得ることを目的とするものである。

【０００５】

【課題を解決する手段】本願で特許請求される発明は以下の通りである。

（１）平均扁平率が１．５～５である非真円形状断面を有する熱可塑性合成繊維マルチフィラメント糸を用いた布帛に金属被膜を形成したことを特徴とする導電性繊維材料。

（２）布帛が織物であることを特徴とする（１）に記載の導電性繊維材料。

（３）熱可塑性合成繊維がポリエステルであることを特徴とする（１）乃至（２）に記載の導電性繊維材料。

（４）織物のカバーファクターが１０００～３０００であることを特徴とする（２）乃至（３）に記載の導電性繊維材料。

【０００６】

本発明の導電性繊維材料に用いる、非真円形状断面を有する熱可塑性合成繊維マルチフィラメント糸における扁平率とは、図１に示すようにマルチフィラメント糸を構成する単糸の扁平断面に外接する長方形を描いたとき、この長方形の長辺

Ｌを短辺Ｈで割った値をいい、その平均扁平率は１．５～５、好ましくは２～４がよい。扁平率が５より大きくなると製糸性、及び、製織性が損なわれ、１．５以下であると導電材の柔軟性が損なわれる。その為には、非真円形状断面糸に外接する長方形の長辺Ｌは１０～５０μｍ、好ましくは２０～４０μｍの範囲がよい。また、非真円形状断面糸に外接する長方形の短辺Ｈは２～３０μｍ、好ましくは６～２０μｍの範囲がよい。単糸繊度は１～１０デニール（以下ｄと表記する）、好ましくは２～５ｄが良い。１ｄ未満になると破断しやすく、製造加工が難しく成る。１０ｄを越えると布帛が硬くなり、柔軟性が得られにくくなる虞がある。本発明の非真円形状断面糸から成るマルチフィラメント糸総繊度は１０～１００ｄ、好ましくは２０～８０ｄの範囲がよい。

【０００７】

単糸断面の扁平形状は楕円、矩形、W型、瓢箪型など特に限定されるものではないが、W型や、瓢箪型など、単糸同士が重なりやすい形状であることが好ましい。重なることにより布帛の表面平滑性が高まり、柔軟性が向上し、且つ、高い電磁波遮蔽効果が得られやすい。

【０００８】

この様な非真円形状断面糸から成るマルチフィラメント糸を用いた布帛としては、織物、編物、不織布など特に限定されるものではないが、導電性繊維材料の厚みや、高いシールド性能の得易さ、及び加工性の点から織物が好ましい。

織物を製織する場合、非真円形状断面糸を、経糸単独、緯糸単独、或いは、経糸、緯糸両方に用いても良い。また、織り組織は平織り、綾織、朱子織、及び、これらの織り方を応用したものなど、特に限定されるものではないが、機械的特性、糸ほつれ性、地薄な面から平織物が好ましい。

本発明の非真円形状断面糸から成るマルチフィラメント糸を用いた布帛は、高密度布帛とした場合に優れた効果が得られる。

【０００９】

本発明の導電性繊維材料に用いられる熱可塑性合成繊維は、ポリエステル、ポリアミド、アクリルなど特に限定はされないが、加工性、耐久性などの点からポリエステルが好ましい。

【００１０】

本発明の非真円形状断面糸を製造する方法としてはカレンダー法や溶融紡糸法などが挙げられるが、均一な非真円形状断面糸を得るには溶融紡糸法が好ましい。

【００１１】

本発明の導電性繊維材料に織物基材に金属被膜を形成したものを用いる場合は、織物のカバーファクターを１０００～３０００、好ましくは１５００～２５００の範囲がよい。

カバーファクターが１０００以下だと布帛の空隙が多くなるため高シールド性が得られにくくなる。また、３０００以上になると、製織性が悪くなるばかりか柔軟性が損なわれ、更にメッキ液が織物内部に浸透しにくくなり、メッキ加工性やメッキ被膜の耐久性に悪影響を及ぼす。

ここで言う織物のカバーファクターとは、経糸総繊度をＤ１、経糸密度をＮ１とし、緯糸総繊度をＤ２、緯糸密度をＮ２とすると、$(D1)^{1/2} \times N1 + (D2)^{1/2} \times N2$で表される。（糸繊度はデニール、糸密度は本／吋）

【００１２】

本発明の非真円形状断面糸から成るマルチフィラメント糸を用いた布帛を金属被覆するには、スパッタリング、真空蒸着、電気メッキ、無電解メッキなど、従来公知の方法を用いることができるが、糸の交点部分での金属被膜形成性の点から無電解メッキによる方法が好ましい。無電解メッキは通常公知の手法で行われ、増感処理、活性化処理、化学メッキ処理からなる。増感処理、活性化処理の目的は、化学メッキ処理以前に触媒貴金属を付着させるための工程であり、メッキの均一性を決定付ける工程である。触媒付与工程には塩化錫溶液による感受性化の後、塩化パラジウム溶液による活性化を行なう方法と錫パラジウムコロイドによる一液性触媒を付与した後、コロイド表面層の錫イオンを除去し触媒として有効なパラジウムを露出させる方法があるが特に限定されない。化学メッキ処理における化学メッキ浴および処理条件については、従来実施されている公知条件で行えばよい。化学メッキ浴は金属塩、還元剤、緩衝剤、ｐＨ調整剤等からなる。導電性金属としては銀、銅、ニッケル、コバルト、錫などがあり、特に限定はされないが、メッキ浴の安定性、操作の容易性から銅およびニッケルから選ばれるこ

とが好ましい。形成する金属メッキ被膜層の厚さは０．１～１０μｍの範囲にあることが好ましい。０．１μｍより小さいと十分な表面導通性が得られず、１０μｍより大きいと表面導通効果はもはや向上せず該繊維材料の風合いも柔軟性が損なわれたものになってしまう。

また、被メッキ物がマルチフィラメント糸からなる布帛の場合、金属被覆の程度は厚みよりも単位面積あたりの析出量や表面抵抗で表現することが多い。その場合金属析出量は５～５０ｇ／ｍ^2、好ましくは１０～３０ｇ／ｍ^{2}の範囲がよく、表面抵抗値は０．００１～１Ω／□、好ましくは０．０１～０．１Ω／□の範囲がよい。

【００１３】

【実施例】以下に実施例を示して本発明の導電性繊維材料を説明するが、本発明は何らこれらに限定されるものではない。

【評価方法】

１．表面導電性

測定方法は抵抗値測定器（三菱化学株式会社製　ロレスターＭＰ）を用い、四端子四探針測定法（ＪＩＳ－Ｋ－７１９４）により表面抵抗値を測定した。単位はΩ／□。

２．電磁波遮蔽性

測定方法は関西電子工業振興センターの生駒電波測定所の考案による測定セルと類似のものを作成し、トラッキングジェネレーター付スペクトラムアナライザー（ヒューレットパッカード社製　ＨＰ８５９１ＥＭ）により１０ＭＨｚ～１ＧＨｚ発振を前述測定セル受信部にて測定サンプルを経て受信し、スペクトラムアナライザーで計量した。単位はｄＢ。

３．金属被膜密着性

布帛表面に形成されている金属被膜の密着性をＪＩＳ－Ｈ－８５０４に準じて評価した。

○　　良い

△　　やや悪い

×　　悪い

４．柔軟可撓性

布帛の柔軟可撓性をＪＩＳ－Ｌ－１０９６Ａ法（４５℃カンチレバー法）に準じて評価した。単位はｍｍ。

【００１４】

【実施例１】

経糸に５０デニール（以下ｄと表す）－２４フィラメント（以下ｆと表す）のレギュラーポリエステルマルチフィラメント糸、緯糸に長辺３５μｍ、短辺１５μｍのＷ型断面糸（旭化成工業株式会社製　テクノファイン）から成る７５ｄ－３０ｆのポリエステルマルチフィラメント糸からなる平織物を、精練プレセット後アルカリ加水分解により１０％の減量加工を行い、経糸密度１２４本／吋、緯糸密度８５本／吋、カバーファクター１５３０の布帛を得た。更に、コンディショニング、キャタライジング、アクセラレート処理を行った後、無電解メッキ法により銅・ニッケル金属被膜層を銅２０ｇ／ｍ^2、ニッケル５ｇ／ｍ^{2}形成させ目的とする金属被覆材料を得た。評価結果を表１に示す。

【００１５】

【実施例２】

経糸に長辺３５μｍ、短辺１５μｍのＷ型断面糸（旭化成工業株式会社製　テクノファイン）から成る３０ｄ－１８ｆのポリエステルマルチフィラメント糸、緯糸に長辺３５μｍ、短辺１５μｍのＷ型異型断面糸（旭化成工業株式会社製　テクノファイン）から成る５０ｄ－３０ｆのポリエステルマルチフィラメント糸を用いた平織物を、精練プレセット後アルカリ加水分解により１０％の減量加工を行い、経糸密度１３５本／吋、緯糸密度１２０本／吋、カバーファクター１５０６の布帛を得た。更に、コンディショニング、キャタライジング、アクセラレート処理を行った後、無電解メッキ法により銅・ニッケル金属被覆被膜層を銅２０ｇ／ｍ^2、ニッケル５ｇ／ｍ^{2}形成させ目的とする金属被覆材料を得た。評価結果を表１に示す。

【００１６】

【比較例１】

経糸と緯糸に５０ｄ－３６ｆのレギュラーポリエステルマルチフィラメント糸

を用いた平織物を、精練プレセット後アルカリ加水分解により１０％の減量加工を行い、経糸密度１６４本／吋、緯糸密度１０４本／吋、カバーファクター１７９８の布帛を得た。更に、コンディショニング、キャタライジング、アクセラレート処理を行った後、無電解メッキ法により銅・ニッケル金属被膜層を銅２０ｇ／ｍ^2、ニッケル５ｇ／ｍ^{2}形成させ目的とする金属被覆材料を得た。評価結果を表１に示す。

【表１】

	実施例１	実施例２	比較例１
付着金属量 (ｇ／ｍ^2)	２５	２５	２５
布帛厚み (μｍ)	７７	９０	１１０
非真円形状断面糸平均扁平率（％）	２．８	２．８	——
表面抵抗 (Ω／□)	０．０３	０．０３	０．０５
シールド効果 １０ＭＨｚ	１００	１０５	１００
５０ＭＨｚ	９５	９６	９０
１００ＭＨｚ	９０	９３	８８
５００ＭＨｚ	８８	８５	８０
１ＧＨｚ	８５	８５	７５
金属被膜密着性	○	○	△
柔軟可撓性 (ﾀﾃ／ﾖｺ)	６２／５４	５８／５２	８５／７９

【００１７】

【発明の効果】以上のように、平均扁平率が１．５～５である非真円形状断面を有するフィラメントが密に重なり合った構造の熱可塑性合成繊維マルチフィラメント糸を用いた布帛に金属被膜を形成して成る導電性繊維材料は、表面が緻密、均一で平滑な金属被膜層を有し、薄厚で繊維本来の柔軟可撓性を損なうこと無く、広い周波数域にわたり高い電磁波遮蔽性能を示す。

【図面の簡単な説明】

【図１】扁平率算出のための概念図の例である。

【図２】本発明の実施例の織物の表面写真である。

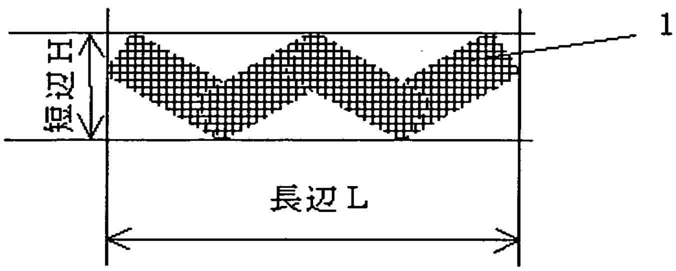
【図３】本発明の実施例の断面写真である。

【符号の説明】

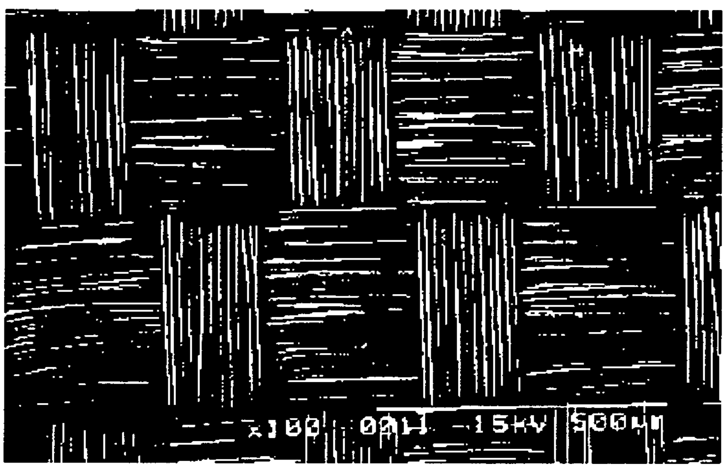
１…単糸

【書類名】　図面

【図１】



【図２】



【図３】

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【書類名】　要約書

【要約】

【目的】繊維本来の柔軟可撓性を損なうこと無く、広帯域にわたり高シールド性能を維持する電磁波遮蔽材及びグランディング材などの導電材として用いる導電性繊維材料を得る。

【解決手段】平均扁平率が１．５～５である非真円形状断面を有する熱可塑性合成繊維マルチフィラメント糸を用いた金属被覆被膜布帛から成る導電性繊維材料。

【選択図】無

出　願　人　履　歴　情　報

識別番号　　　　〔０００１０７９０７〕

１．変更年月日　　１９９０年　８月３０日
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Susumu TAKAGI et al.

Serial No: 09/731,935

Filed: December 7, 2000

For: **METAL COATED FIBER MATERIALS**

Examiner: Alexis A. Wachtel

Group Art Unit: 1771

Docket: 188-84

Assistant Commissioner for Patents
Washington, DC 20231

VERIFIED STATEMENT

I, Takehiko Saito, hereby state that:

1. I am knowledgeable in the English language and in the Japanese language;

2. I have read the English translation of Japanese Appln. No. 348210/1999 from which priority is claimed for U.S. Application No. 09/731,935.

3. I have read Japanese Appln. No. 348210/1999;

4. The English translation of Japanese Appln. No. 348210/1999 is an accurate translation;

5. A true and accurate copy of the English translation is attached hereto;

6. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this Verified Statement is directed.

Date: November 6, 2002

Takehiko Saito

PATENT OFFICE

JAPANESE GOVERNMENT

This is to certify that the annexed is a true copy of the following application as filed with this Office.

Date of Application	:	December 7, 1999
Application Number	:	348210/1999
Applicant	:	SEIREN CO., LTD.

January 5, 2001

Commissioner,
Patent Office

Kozo OIKAWA

Certified No. 2000-3108733

PATENT APPLICATION

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Messrs: Commissioner, Patent Office

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Payment:

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Attachments:

Document Name:	Specification	1
Document Name:	Drawing	1
Document Name:	Abstract	1

[Document] SPECIFICATION

[Title of the Invention]

METAL COATED FIBER MATERIALS

[Claims]

1. An electrically conductive material comprising fabric constructed of multifilament yarn composed of a plurality of flat thermoplastic singlefilaments and a metal coating layer formed on the surface of the fabric, said flat singlefilaments having an average flat ratio of 1.5 to 5.0.

2. The electrically conductive material as claimed in claim 1, wherein said fabric is woven fabric.

3. The electrically conductive material as claimed in claim 1 or 2, wherein the thermoplastic fiber constituting said woven fabric is polyester.

4. The electrically conductive material as claimed in claim 2 or 3, wherein said woven fabric has a cover factor of 1000 to 3000.

[Detailed Description of the Invention]

[Field of the Invention]

This invention relates to an electrically conductive fiber material suitable for use as electromagnetic interference (EMI) shielding, grounding and other electrically conductive parts.

[Background of the Invention]

Electrically conductive fabrics have been widely

used in various electronic apparatus to prevent leakage of electromagnetic waves from the apparatus. Among them is fabric of synthetic fiber, made of polymer material such as polyester or nylon, with a metal coating formed on its surface, which is characterized by its two combined characteristics - flexibility from its fiber component and EMI shielding performance from its metal component - finding wide application in the field of gaskets and tapes to be built into electronic apparatus.

The recent development of electronic apparatus reduced in size and increased in frequency has required the development of electrically conductive materials, such as EMI shielding and grounding materials, smaller in thickness and more effective especially in a high frequency region. It is known that metal foil and polymer film coated with metal by deposition or spattering meet these requirements. Such materials, however, have the disadvantages of being lacking in durability, flexibility and softness, which are properties required for their use as EMI shielding and other electrically conductive materials.

JP64-30899A discloses a non-woven fabric for use as an EMI shielding sheet material obtained by bonding a metal plated fiber with a flat cross-section and a thermally melting binder fiber together by melting of said binder fiber. However, this non-woven fabric bases its improved shielding performance on the thermal compression binding of

the thermally melting binder fiber to the metal plated fiber, which adversely affects its flexibility and also requires extra steps making its manufacture expensive.

JP8-291432A discloses a flexible woven fabric effective in shielding EMi obtained from a metal monofilament with a flat non-round section spirally wound onto a core yarn composed of 10 or more fibers. This fabric, however, has the disadvantage of requiring an increased amount of the metal monofilament to obtain a satisfactory EMI shielding effect, which, in turn, adversely influences its flexibility, as well as its cost performance.

[Object of the Invention]

The present invention has been made against the background of the prior art involving the above-mentioned technical problems. It is therefore an object of the present invention to provide an electrically conductive fabric, which maintains the flexibility of its fiber substrate and has high EMI shielding performance over a broadband, finding wide application in the field of electrically conductive materials such as EMI shielding and grounding.

[Means for Attaining the object]

The present invention as claimed are as follows:

1. An electrically conductive fiber material which comprises a fabric constructed of multifilament yarn composed of a plurality of flat thermoplastic singlefilaments and a metal coating layer formed on the surface of the fabric, said

flat singlefilament having an average flat ratio of 1.5 to 5.0.

2. The electrically conductive material as claimed in the above 1, wherein said fabric is woven fabric.

3. The electrically conductive material as claimed in the above 1 or 2, wherein the thermoplastic fiber constituting said woven fabric is polyester.

4. The electrically conductive material as claimed in the above 2 or 3, wherein said woven fabric has a cover factor of 1000 to 3000.

The average flat ratio of a flat singlefilament useful in manufacturing electrically conductive fiber material of the present invention refers to the value determined by drawing a rectangle circumscribed along the cross-section of the flat singlefilament as illustrated in Fig. 1 and dividing the long side (L) of the rectangle by its short side (S), which is normally in the range of 1.5 to 5, preferably 2 to 4. As found in the process of the present invention, a flat singlefilament with an average flat ratio of more than 5 has a problem with its processing into multifilament yarn and fabric, while the one, whose average flat ratio is 1.5 or below, causes a problem with the flexibility of the electrically conductive fabric resulting from it. To eliminate these problems, the flat singlefilament of the present invention has a cross-section, the circumscribed rectangle of which has normally a long side

(L) of 10 to 50 μm, preferably 20 to 40 μm, and a short side (S) of 2 to 30 μm, preferably 60 to 20 μm. The size of the flat singlefilament according to the present invention normally is 1 to 10 deniers (hereinafter abbreviated as "d"), preferably 2 to 5d. A flat singlefilament with a size less than 1d may has a problem with its strength not sufficient for its satisfactory processing into yarn and fabric, while the one, whose size is more than 10d, may cause a problem with the flexibility of the fabric resulting from it. The total size of the multifilament yarn composed of flat singlefilaments according to the present invention is normally 10 to 100d, preferably 20 to 80d.

The shape of the cross-section of singlefilament according to the present invention includes, without limitation, ellipse, rectangle, W and hourglass. Among singlefilaments with cross-sections of these shapes, however, ones with a cross-section shaped like W or hourglass are preferable for the present invention, because such a shape allows the singlefilaments to fit in closely with one another when processed into a multifilament, which, in turn, can yield a fabric smooth in surface and small in thickness, contributing to its improved flexibility and higher EMI shielding performance.

The fiber material constructed of such multifilament yarn composed of flat singlefilaments according to the present invention includes, without limitation, woven

fabric, knitted fabric and non-woven fabric. Among these fabrics, however, woven fabric is preferable for the present invention, because it can yield an electrically conductive material which is advantageous in thinness, high EMI shielding performance and ease of processing into secondary products.

Useful woven fabric of the present invention may be manufactured using the multifilament composed of flat singlefilaments, as referred to in the present invention, for its warp of weft alone, or both thereof, whether in part or whole. The weave of woven fabric according to the present invention includes, without limitation, plain, twill and satin, and any combination thereof. Among these weaves, however, plain weave is preferable for the present invention because it is advantageous in mechanical properties, yarn fray resistance and thickness.

The fabric of the present invention made by the multifilament composed of flat singlefilaments according to the present invention is preferably used in the form of higher density fabric.

The thermoplastic fiber useful in manufacturing the electrically conductive materials of the present invention includes, without limitation, polyester fiber such as polyethylene terephthalate fiber, polyamide fiber and acrylic fiber. Among these fibers, however, polyester fiber is preferable for the present invention because it is

advantageous in durability and ease of processing into flat singlefilament, multifilament and fabric.

The flat singlefilament of the present invention may be manufactured by methods including, but not limited to, calendering and melt spinning. Among these methods, however, the melt spinning method is preferable for the present invention because it can manufacture a singlefilament uniform in flatness. If a woven fabric is used as a substrate on which a metal coating layer is formed for manufacturing of the electrically conductive material of the present invention, usually the fabric has a cover factor of 1000 to 3000, preferably 1500 to 2500.

Fabric with a cover factor of less than 1000 may has a problem of increased size of openings at the intersections of the fabric, resulting in deteriorted EMI shielding performance of the electrically conductive material. Conversely, fabric with a cover factor of more than 3000 may has a problem not only with its awkward manufacture, but also with its poor flexibility due to its high density, which also causes poor penetration of a plating solution through it, adversely affecting the ease of its plating and the durability of the resultant metal coating formed on it.

The cover factor of woven fabric referred to in the present invention is the value determined by its design factors - total warp size (D1), warp density (N1), total weft

size (D2) and weft density (N2) according to the following formula:

(D1)1/2 x N1 + (D2)1/2 x N12, where the yarn size is expressed in deniers and the yarn density in yarns/inch.

Metal coating of fabric constructed of thermoplastic multifilament yarn composed of flat singlefilaments as referred to in the present invention to manufacture an electrically conductive material may be achieved by using methods such as spattering, vacuum deposition, electroplating and electroless plating that have been disclosed in various prior art references for such coating. Among these methods, however, electroless plating is preferable for the present invention because it is advantageous in that it can metal-plate fabric with formation of a metal coating at the intersections of its yarns. Electroless plating of fabric according to the present invention may be carried out according to well-known procedure which has a step of applying a catalyst to the fabric, followed by a step of its chemical plating. For the catalyst applying step, the present invention may use either of the two known methods: one is by sensitizing fabric with an aqueous solution of tin chloride, followed by treatment of the fabric with an aqueous solution of palladium chloride, and the other is by applying a one-solution catalyst of tin-palladium colloid to fabric, followed by removal of tin ions on its colloidal surface layer for exposure of palladium

effective as a catalyst for its chemical plating. The chemical plating process may be performed using plating bath and conditions known by those skilled in the art. The chemical plating bath normally contains a metal salt, reducer, buffer, pH controller and other agents necessary to achieve the purpose of the present invention.

Conductive metals useful in plating fabric to manufacture electrically conductive materials of the present invention includes, without limitation, silver, copper, nickel, cobalt and tin. Among these metals, however, copper and nickel are preferable for the present invention because both metals are advantageous in providing a plating bath stable and easy to handle. The plating of fabric according to the present invention may preferably be carried out so that the thickness of the metal coating formed on the fabric is in the range of 0.1 to 10 μm.

Fabric plated with a metal coating thickness of less than 0.1 μm may fail to provide a sufficient surface conductivity to convert the fabric into an electrically conductive material referred to in the present invention. Conversely, fabric plated with a metal coating thickness of more than 10 μm may fail to show any further increase in its surface conductivity due to such a thick metal coating, which only contributes to its deteriorated flexibility.

In general, metal plating of any substrate is evaluated for a degree of metal coating formed on the

substrate in terms of metal deposition per unit area or surface resistance more often than in terms of thickness. In this respect, the metal plating of fabric according to the present invention may be performed so that the fabric has a metal deposition of 5 to 50 g/m^2, preferably 10 to 30 g/m^2, and a surface resistance of 0.001 to 1 $\Omega/\square$, preferably 0.01 to 0.1 $\Omega/\square$.

[Examples]

The present invention will be understood more clearly with reference to the following Examples; however, these examples are intended to further illustrate the present invention and are not to be construed to limit the scope of the present invention.

[Evaluation]

1. Surface conductivity

A resistance measuring device (Mitsubishi Chemical Corporation-made Loresta-EP MCP-T360) was used to measure each test sample for surface conductivity in $\Omega/\square$ according to the four-terminal four-probe measurement method (specified by JIS-K-7194).

2. EMI shielding performance

A measuring cell similar to the one devised by Kansai Electronic Industry Development Center (KEC)'s Ikoma Testing Station was prepared to receive 10MHz to 1GHz generated from a spectrum analyzer with a tracking generator (Agilent

Technology-made HP8591EM) at the measuring cell's receiving unit through a test specimen of the fabric set in the cell to measure its EMI shielding performance in dB over the 10 MHz to 1GHz region with the spectrum analyzer

3. Metal coating adhesion

JIS-H-8504 was used to evaluate the adhesion of the method coating formed on the fabric.

○ good

△ slightly bad

x bad

4. Flexibility

JIS-L-1096 Method A (known as 45° Cantilever Method) was used to measure a test specimen of the fabric in mm for evaluation of its flexibility.

[Example 1]

A plain weave fabric with 50 denier (hereinafter abbreviated as "d")-24 filament (hereinafter abbrevited as "f") regular polyester multifilament textured yarn for its warp and 75d-36f polyester multifilament yarn (composed of singlefilament with a W-shaped cross-section, whose circumscribed rectangle has a long side (L) of 35 μm and a short side (S) of 15 μm - Asahi Chemical-made Technofine) for its weft was scoured, dried and heat-preset and subjected to a surface etching treatment by caustic hydrolysis for weight reduction by 10% to convert the fabric into one with a warp

density of 124 yarns/inch, a weft density of 85 yarns/inch and a cover factor of 1530.

The fabric was subjected to a conditioning catalyzing and accelerating treatment, followed by electroless copper and nickel platings to obtain an electrically conductive material with a metal coating layer consisting of 25g/m^2 of copper and 5g/m^2 of nickel. The metal coated textile material was subjected to the above-mentioned evaluation, the result of which is as shown in Table 1.

[Example 2]

A plain weave fabric with 30d-18f polyester multifilament yarn (composed of singlefilament with a W-shaped cross-section, whose circumscribed rectangle has a long side (L) of 35 μm and a short side (S) of 15 μm - Asahi Chemical-made Technofine) for its warp and 50d-30f polyester multifilament yarn (composed of singlefilament with a W-shaped cross-section, whose circumscribed rectangle has a long side (L) of 35 μm and a short side (S) of 15 μm - Asahi Chemical-made Technofine) for its weft was scoured, dried and heat-preset before being caustic treatment for weight reduction by 10% to convert the fabric into one with a warp density of 135 yarns/inch, a weft density of 120 yarns/inch and a cover factor of 1506.

The fabric was immersed in an aqueous solution containing 0.3g/L of palladium chloride, 30g/L of stannous

chloride and 300ml of 36% hydrochloric acid and then washed with water. Thereafter, the fabric was immersed in a solution of borofluoric acid with an acid concentration of 0.1N and then washed with water. The fabric was subsequently immersed in an electroless copper plating bath consisting of 7.5g/L of copper sulfate, 30ml/L of 37% formalin and 85g/L of Rochelle salt and then washed with water. The copper-plated fabric was further immersed in an electronickeling bath consisting of 300g/L of nickel sulfamate, 30g/L of boric acid and 15g/L of nickel chloride at a pH of 3.7 with a current density of 5A/dm to build up a nickel layer on it before washing it with water to obtain an electrically conductive material with a metal coating layer consisting of 20g/m^2 of copper and 5g/m^2 of nickel. The metal coated material was subjected to the above-mentioned evaluation, the result of which is as shown in Table 1.

[Comparative Example 1]

A plain weave fabric with 50d-36f regular polyester multifilament textured yarn for its warp and weft was scoured, dried and heat-preset before being caustic treatment for weight reduction by 10% to convert the fabric into one with a warp density of 164 yarns/inch, a weft density of 104 yarns/inch and a cover factor of 1798.

The fabric was subjected to a conditioning, catalyzing and accelerating treatment, followed by electroless copper-nickel platings to obtain an electrically

conductive material with a metal coating layer consisting of 20g/m2 of copper and 5g/m2 of nickel. The metal coated material was subjected to the above-mentioned evaluation, the result of which is as shown in Table 1.

Table 1

		Example 1	Example 2	Comparative Example 1
Coated metal amount (g/m^2)		25	25	25
Fabric thickness (μm)		77	90	110
Average flat rate (%)		2.8	2.8	-
Surface conductivity ($\Omega/\square$)		0.03	0.03	0.05
EMI shielding Performance (dB)	10MHz	100	105	100
	50MHz	95	96	90
	100MHz	90	93	88
	500MHz	88	85	80
	1GHz	85	85	80
Metal coating adhesion		○	○	△
Flexibility (mm) (warp/weft)		55/42	37/37	75/45

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[Effects of the Invention]

As can be seen from Table 1 fabric constructed of thermoplastic synthetic fiber multifilament yarn composed of densely overlapped flat singlefilaments allowing the multifilament yarn to have an average of 1.0 to 8.0, when chemically plated with metal, can yield an electrically conductive material small in thickness with a metal coating layer, whose surface is fine, uniform and smooth, maintaining the flexibility of the fabric and showing high EMI shielding performance over a wide frequency range.

[Brief Description of the Drawings]

Fig. 1 is a conceptual cross-sectional view of the flat singlefilament of the present invention for calculation of its compression.

Fig. 2 is a conceptual cross-sectional view of the multifilament yarn of the present invention for calculation of its compression.

Fig. 3 is a photo showing the surface of the woven fabric used in the examples of the present invention.

[Legends]

1 ... Singlefilament

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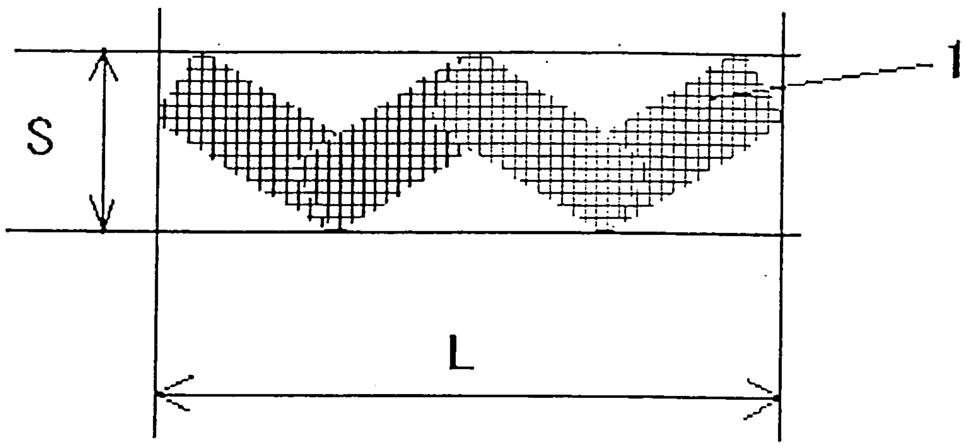

FIG. 1

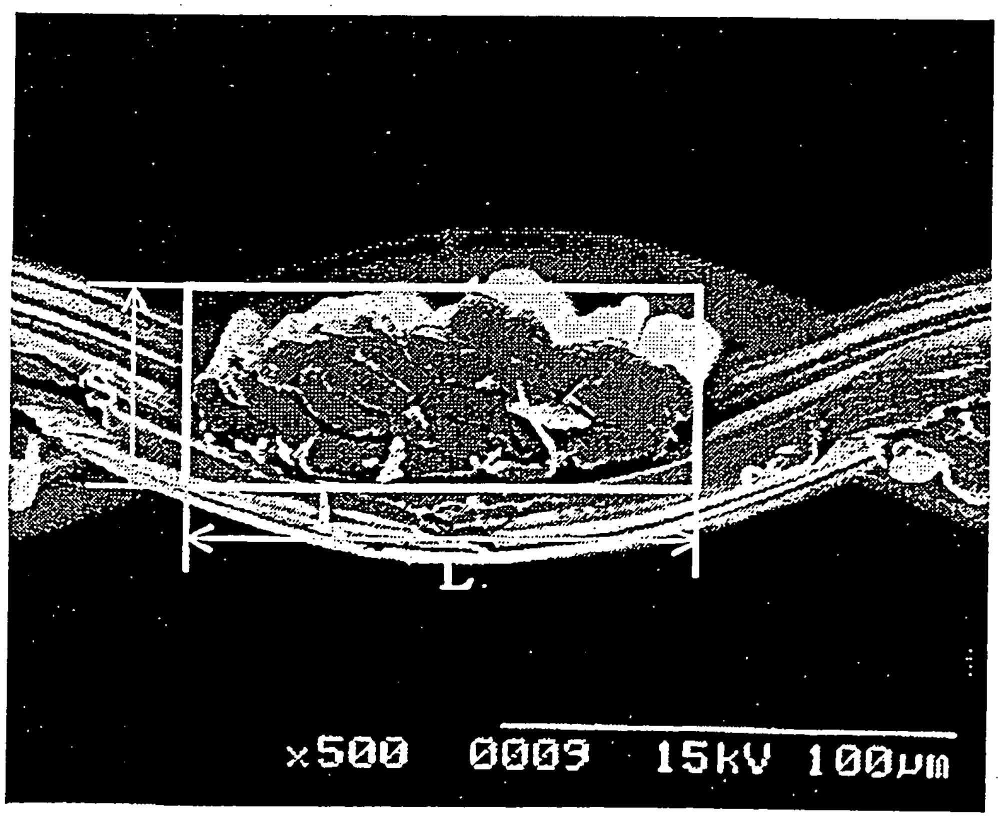

FIG. 2

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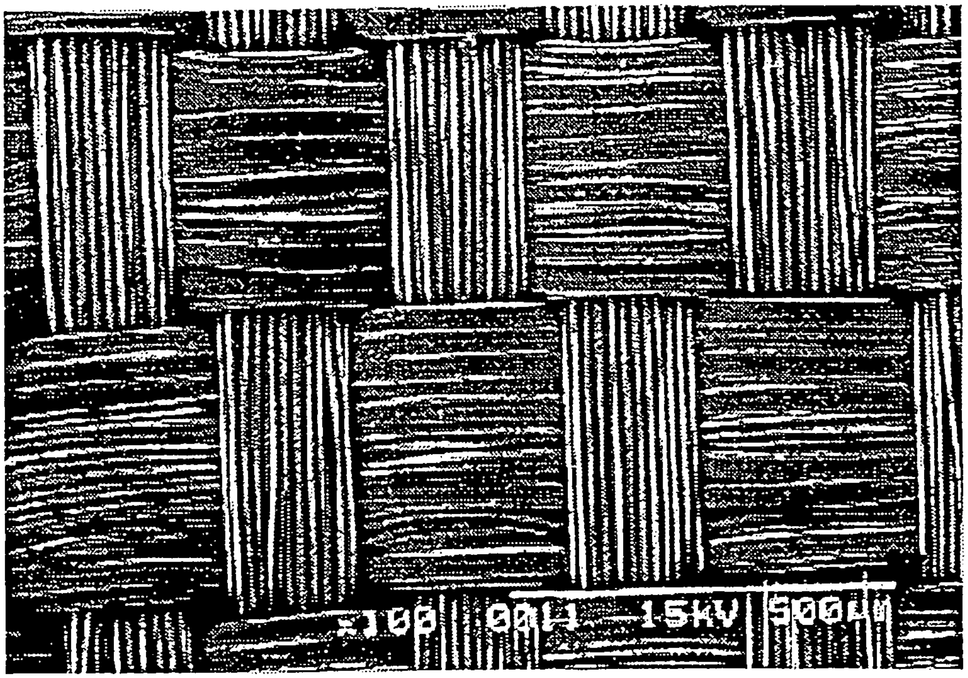

FIG. 3

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ABSTRACT

[Object]

To obtain an electrically conductive fabric, which maintains the flexibility of its fiber substrate and has high EMI shielding performance over a broadband, finding wide application in the field of electrically conductive materials such as EMI shielding and grounding.

[Means for Attaining the Object]

An electrically conductive fiber material which comprises a fabric constructed of multifilament yarn composed of a plurality of flat thermoplastic singlefilaments and a metal coating layer formed on the surface of the fabric, said flat singlefilaments having an average flat ratio of 1.5 to 5.0.